Artificial Wombs

Delivering on Fertile Promises

By Colleen Carlston

Just over 30 years ago on July 25, 1978 the first test-tube baby, Louise Joy Brown, was born in England(1). She was heralded as Super Babe by the papers but since that time reproductive science has improved to the point where in-vitro fertilization (IVF) is a routine procedure in fertility clinics around the world. At this point some 4 million babies have been conceived using IVF(2). This has enabled numerous couples that otherwise might have remained childless to conceive. Sperm and egg donors and surrogate mothers have further expanded the possibilities for those wanting a family. However, for many the price of hiring a surrogate remains prohibitively high and increasingly couples have been out-sourcing their childbearing to women living in developing countries(3). Yet this carries its own risks when it comes to ensuring proper prenatal care conditions and what can be done when a surrogate changes her mind about keeping the baby.

Experiments involving nuclear transfer into an egg may soon mean that even a 75-year-old man could create an embryo using a donor egg and swapping the nucleus for his own(4). Alan Trounson, the director of the California Institute for Regenerative Medicine in San Francisco, believes, “it will be possible that we’ll be able to extend the fertile period for women by...
producing germ cells from iPS [induced Pluripotent Stem-cell] technology, or by a variant of nuclear transfer, so somatic cells [which make up most of the body’s cells] become germ cells and are refreshed genetically”(1). The limiting step will therefore probably not be how to make the embryo, but what to do with it when a suitable uterus is not easily available.

Professor Hung-Ching Liu at Cornell University’s Center for Reproductive Medicine has been growing endometrial tissue (the uterus lining) since 2001 and firmly believes it is possible for fetuses to be grown outside a woman’s uterus(5). In 2003 a mouse embryo grew to almost full term (it was moving and breathing) in an endometrial tissue “bubble” but died just a few days later. In a similar line of research, Professor Yoshinori Kuwabara at Juntendo University in Tokyo worked with incubating goat fetuses in plastic tanks containing an amniotic fluid-like liquid and using a pump connected to the umbilical cord (6).

So why has relatively little attention been paid to research that could lead to a major change in reproductive capacity? In fact, much work goes unpublished because of the uproar it might create among activists, politicians, and religious figures for its social implications. Or worse, the premature hope it might instill in would-be parents. When Professor Liu first announced her preliminary results in 2001 she was bombarded with calls from infertile women begging to be test subjects(5). She was so affected by this that she halted her research into artificial wombs for a year while she contemplated the trajectory her research would take. She ultimately decided to continue because of the hope that she can help women with damaged uteriuses to conceive(5).

How to Build an Artificial Womb

In creating an artificial womb, Dr. Liu appropriated techniques developed for making artificial skin used in grafts(5). Collagen and chondroitin, both biodegradable, formed a matrix for the harvested endometrial cells to grow upon. This matrix conformed to the organism’s natural uterine shape, so the human artificial uterus was bowl-shaped while the mouse’s was a doughnut-shaped section to mimic its tubular uterus. Over time the matrix itself decayed leaving only the endometrial tissue whose growth was fueled by hormones and growth factors.

In the mouse model, Dr. Liu placed embryos on this artificial uterus and watched them implant and develop. After 10 days she moved some of the embryos back into natural wombs. After 17 days she removed all embryos and found that those left in vitro died before reaching full term (21 days); however, the embryos that had been implanted back into mice seemed small but otherwise normal(7). The endometrium produced to help support embryo growth and so was key to having the mice continue to develop outside the womb. Dr. Liu has also grown human embryos to 10 days in artificial wombs but no further because current federal regulation in the United States prevents growing human embryos beyond two weeks in a lab(4).

Ideally, embryos could implant in the artificial womb and at some point this whole structure could be implanted back into the woman. Since it would have been grown using the woman’s own cells there would be no fear of organ rejection(8). Liu then tried implanting mice artificial wombs carrying embryos into adult mice; however, they failed to survive, most likely because the
blood vessels that normally connect the mother and the fetus formed improperly(5). To address this, Liu’s colleague studied murine AGPAT, which is a gene that stimulates blood-vessel formation within the uterus. Women in whom this gene is missing or mutated tend to miscarry. This gene could also have implications for cancer treatment, since tumors likewise rely on blood vessel networks to receive nutrients and expel waste.

While Dr. Liu has been working to help those who have trouble conceiving, Dr. Kuwabara has been working from the other end of gestation: to help women who suffer miscarriages or very premature births(8). In 2000, he fabricated an acrylic box containing a mixture of sodium and potassium chloride, glucose and proteins kept at 39.5 degrees Celsius to mimic the amniotic sac. Into this box he placed 4-month old goat fetuses removed by Caesarean section and connected their umbilical cords to an artificial placenta(5). While most children died some survived for three weeks, reaching full term for a goat but all were deformed or had lung problems. Since the 42-liter container was larger than a normal womb the fetuses could have been overly active and taken in too much oxygen, which is toxic at high concentrations. Also, by swallowing too much amniotic fluid fetuses could suffer severe fluid retention. As a preventative measure the fetuses were fed sedatives to slow down activity and swallowing. However, a month-old child birthed using these techniques suffered after-effects of the sedatives and could neither stand nor breathe on its own (6). This was unfortunate considering one aim of this research was to redress hypoplasia, a form of underdevelopment of the lungs, one of the major causes of death in premature infants unable to breathe, which kills around 100 babies each year in Japan alone(6). Dr. Kuwabara eventually gave up this line of inquiry, but similar experiments are now being employed in Australia in an attempt to restore declining nurse shark populations(9).

It is also important to determine how liquid media should be adjusted during the course of pregnancy. Even incremental changes in hormone or protein levels can have major effects on the offspring. During gestation, the embryo implants and a placenta and amniotic sac form between the embryo and the womb. Hormones, nutrition, blood, oxygen, and waste pass through the placenta as needed. Think of it as a high-end aquarium, but a even more complicated. Even IVF treatments have difficulty creating as good an environment for early embryonic development, and a new invention by the Swiss company Anecova tries to circumvent this shortcoming. They created a 5mm long and less than 1 mm wide perforated silicon capsule that can carry lab-created embryos and be placed inside a woman’s uterus(10). This provides a more natural environment for the 2 to 5 days fertility clinics grow embryos before selecting the healthiest for implantation into the womb. Currently these early embryos are incubated in a growth medium that must be changed every few hours. Critics say this new treatment is unlikely to succeed since eggs naturally develop in the fallopian tubes rather than the uterus. However, if this device can create a higher success rate, it means that fewer eggs will have to be harvested from women. Most IVF treatments now require women to take hormones kick egg production into overdrive, which can sometimes lead to dangerous side-effects.

Women and the Artificial Womb

In Aldous Huxley’s futuristic Brave New World published in 1932, babies grew in tubes. In 1970 Shalumith Firestone wrote in The Dialectic of Sex: The Case for Feminist Revolution that...
artificial wombs should be developed to free women from “the tyranny of their sexual-reproductive roles” (5). Indeed, even the Raelian cult announced they had developed a “Babytron” that could incubate an embryo from conception onward. These examples may seem extremist or even farcical, but there is no denying that there has long been a fascination about giving birth to children without the need for women to do so, and the ways this could affect society.

Beyond imagining new world orders, there are also some pragmatic reasons for why artificial wombs might be employed. These artificial births would be completely safe for the mother, offering no chance of hemorrhaging during birth. Women also would not have to take time away from busy careers for maternity leaves. Yet, there is also the danger that companies would become increasingly reluctant to grant lengthy maternity leaves knowing they were no longer technically necessary (8).

Other women might want artificial wombs for more superficial reasons, to avoid weight gain or stretch marks. Somewhat more sympathetically, they may want their husbands to “share the burden” by having an artificial womb implanted and carrying some of their children. But there already exists a perfectly viable alternative: surrogate mothers. Although mothers may be squeamish about having other woman carry their children, it hardly seems worth risking the baby’s health in an experimental procedure. Children from artificial wombs, even if they turned out physically normal, might have missed out on some intrauterine emotional development. Janet DiPietro, a developmental psychologist at Johns Hopkins University, believes that mother-embryo interactions that occur during pregnancy are essential (5). She suggests that mothers play an important role in socializing with their children from the start and that fetuses moving around in the womb are teaching their mothers to pay attention to them.

It is possible though that if artificial wombs were deemed safe and became economically competitive with other forms of gestation, health insurance companies might try to infringe on this stage of mother-embryo bonding (5). After all, as not all women are responsible mothers after they give birth it is unreasonable to expect that they all would be prior to this. Health insurance companies could insist that women opt for the artificial way, since natural wombs can be invaded by drugs and alcohol from a mother’s body (7). Premature birth and fetal alcohol syndrome can occur when mothers are reckless or unaware of their pregnancies.

Social Issues

Surprisingly, many religious groups that are strongly against abortion and stem cell research have come out in favor of artificial wombs. The reason is that abortion laws tend to rely on the non-viability of the fetus outside the womb. Forty states and the District of
Columbia restrict abortion to within the first 24 weeks, after which a fetus could likely survive birth(5). An artificial womb could significantly extend fetal viability outside the mother’s body, and thereby, some would argue, not infringe on the mother’s rights. Scott Gelfant, the director of the Ethics Center at Oklahoma State University in Stillwater explains, “some might think that it could meet the test of Roe vs Wade – that it protects the privacy of the woman while preserving the rights of the fetus. If an artificial womb were developed, the government could pass a law that required people who have a termination of pregnancy to put the fetus into one of these wombs... There are around 1 million abortions per year in the United States and there would have to be labs throughout the country, but if we put all these in artificial wombs and then put them up for adoption we would have one million more babies. It would be a nightmare”(1). At the very least, if women were given the option of transferring their embryos to an artificial womb to be carried to full term it might dissuade them from having abortions. The danger is that this would leave the adoption services overburdened and put many more children into flawed foster care systems.

It is essential to remember that fertility is just half the equation. Providing for the children already present and preventing unwanted pregnancies should also be priorities. Régine Sitruk-Ware, a reproductive endocrinologist at the Population Council in New York, cautions, “If we look at centers in reproductive sciences funded by the National Institutes of Health, there are more than twenty on IVF and only a handful on contraceptive research. It’s more politically correct to help people get babies than the reverse, but it’s important to have a balance”(1).

When artificial womb technology comes into effect, laws will certainly have to be revised. Currently New Hampshire law says, “No pre-embryo that has been donated for use in research shall be transferred to a uterine cavity”(7). What about if there is no further need for the uterus? For this reason, some recommend that the US develop an institution analogous to Britain’s Human Fertilization and Embryology Authority to help resolve such quandaries(11). Artificial womb research has great potential and now it is our responsibility to ensure it delivers more happiness than heartache.

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References